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Preoperative Tattooing for Precise and Expedient Localization of Landmark in Laparoscopic Liver Resection

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Laparoscopic liver surgery is a safe and effective approach for the management of surgical liver disease in the hands of trained surgeons who are experienced in hepatobiliary and laparoscopic surgery.[1-10] Intraoperative ultrasound (IOUS) has become an important pillar of modern surgery with diagnostic and therapeutic value; it has become an almost indispensable procedure for the intraoperative diagnosis of liver lesions. It is also beneficial for guidance to the parenchymal transection plane with immediate feedback on any changes that might occur during surgery in not only open hepatic surgery,[11,12] but also laparoscopic hepatic surgery.[13-15] However, during laparoscopic hepatectomy, the reliability of laparoscopic IOUS has been poor when evaluating the entire liver because interpretation of the ultrasound image is challenging. It is often difficult to localize liver lesions during laparoscopy with IOUS or palpation via a laparoscopic approach, particularly if they are small or on the deep side of an intraparenchymal lesion; precise localization of a lesion or a vessel landmark is critical to achieving adequate surgical margins.[16-18]

To address this issue, we have demonstrated that preoperative tattooing allows the surgeon to determine the precise and expedient localization of a landmark or tumor during laparoscopic liver resection.

MATERIALS AND METHODS

Patients

From February 2008 to June 2014, one hundred and six laparoscopic hepatectomies were performed at our institution. Seven of the patients underwent preoperative tattooing for laparoscopic liver resection. Details of the patient characteristics are presented in Table 1.

Preoperative tattooing

Ultrasound was routinely performed by 2 surgeons. Immediately after administration of general anesthesia and identification of the lesion, an 18-gauge fine needle (Sonoguide PTC needle type B; Hakko Co.) was inserted at the margin of the lesion and 1 mL sterile purified Crystal Violet (Pyoktanin blue solution; Kishida Chemical Co., Ltd) was injected under direct ultrasound visualization. In addition, tattooing was performed using 1 mL sterile dye injected surrounding the anatomical landmarks (portal branches) (Fig. 1).

Laparoscopic procedure

A pneumoperitoneum was maintained throughout the procedure on a high flow rate with CO_2 at a pressure of 12 mmHg; a laparoscope was usually inserted in this pneumoperitoneum. The operation was performed via two 12-mm and two 5-mm trocars placed along the line of the costal margin, depending on the site of the liver tumor. In general, one 12-mm trocar and one 5-mm trocar were inserted into one side and one 12-mm and 5-mm into the other. The Pringle maneuver was applied through an additional 12-mm incision in the mid-upper abdomen. Laparoscopic IOUS was performed in all patients to obtain additional information about the free surgical margin and the anatomic relationship between the vessels and the tumor. To perform more limited resections, such as anatomic subsegmentectomies or nonanatomic wedge resections, the feeding Glissonian pedicles that had to be divided and the surgical margin indicated by preoperative tattooing were identified as high echoic lesions. This map was the basis for planning the resection. During the transection, once the local landmarks were identified, we stopped the dissection when the tattoo was easily visible with adequate exposure (Fig. 2). In addition, the vessels with the tattoo were dissected and clipped, and we continued to transect the liver parenchyma using an ultrasonically activated device.

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Table 1. Patient Characteristics and Pathological Variables

Patient characteristics	Data (n = 7)
Age, y, median (range)	64.9 (54–78)
Male/female, n	4/3
Histology, n	
Hepatocellular carcinoma	4
Colorectal carcinoma	2
Uterine cervical carcinoma	1
Background liver status, n	
Normal/chronic hepatitis/cirrhosis	3/3/1
Child-Pugh score	5.1 (5–6)
ICG R15, %	13 (3–38)
Localization of tumor	
S4	2
S5	2
S6	3
Tumor number, median (range)	1.3 (1–3)
Size of largest tumor, mm, median (range)	15 (6–27)

ICG R15, indocyanine green retention rate at 15 minutes.

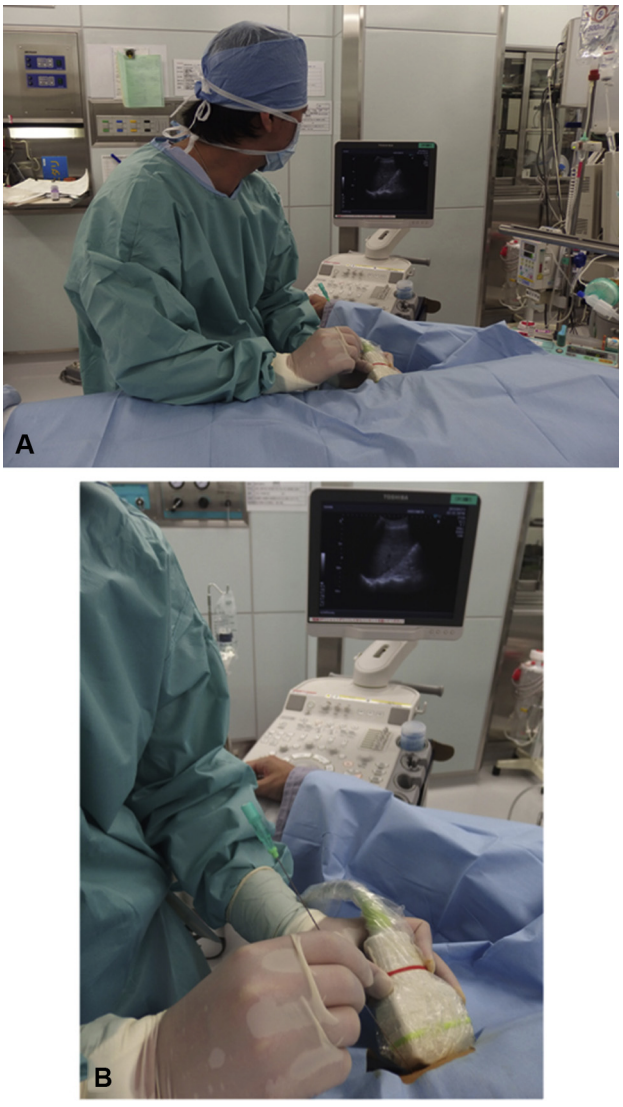

Figure 1. (A) Preoperative ultrasound-guided tattooing of hepatic landmarks. (B) An 18-gauge fine needle was inserted at the margin of the lesion.

RESULTS

The placed tattoo was easily visible in the transection plane of the liver in all 7 patients at laparoscopy. The patients with a tattoo had adequate surgical margins (median 6.3 mm; range 5 to 12 mm). There were no complications associated with preoperative ultrasound-guided tattooing. Median duration of surgery was 169 minutes (range 60 to 365 minutes). Median operative blood loss was 82.9 g (range 5 to 335 g). Median warm ischemic time was 21.4 minutes (range 0 to 150 minutes) (Table 2). Postoperative complications occurred in one patient and were grade 1 according to the Clavien-Dindo classification (Table 3). No liver-related morbidity occurred. Median length of hospital stay for these patients was 8.7 days (range 6 to 12 days).

DISCUSSION

Laparoscopic liver resection has been more commonly performed for hepatic tumors since laparoscopic liver resection was initially described by Reich and colleagues.[5] Recently, there has been an increasing number of reports on laparoscopic liver resections performed for a range of indications.[1-10] One of the challenges faced by surgeons performing laparoscopic hepatectomies is that it can be difficult to identify an invisible hepatic tumor in the laparoscopic field, even when IOUS is performed laparoscopically; this is because palpitation is unavailable and the sensitivity of the ultrasound is decreased. When IOUS is performed laparoscopically, an inability to localize the lesion can lead to exposure of a tumor or not locating invisible tumors. Although the assessment of an intra-abdominal organ should be performed on 2 separate planes (longitudinal and horizontal plane) to confirm that a mass is really present,[14,15,19,20] it is difficult for laparoscopic IOUS to identify 2 separate planes in the whole liver. In addition, contrast-enhanced ultrasound is not available for laparoscopy in the United States. This is a limitation in laparoscopic liver resection and can cause problems when surgeons try to locate small liver lesions identified during MRI or contrast-enhanced ultrasound. Another challenge is that laparoscopic nonanatomic partial resections are often more challenging than major hepatectomies in which the resection line is indicated by

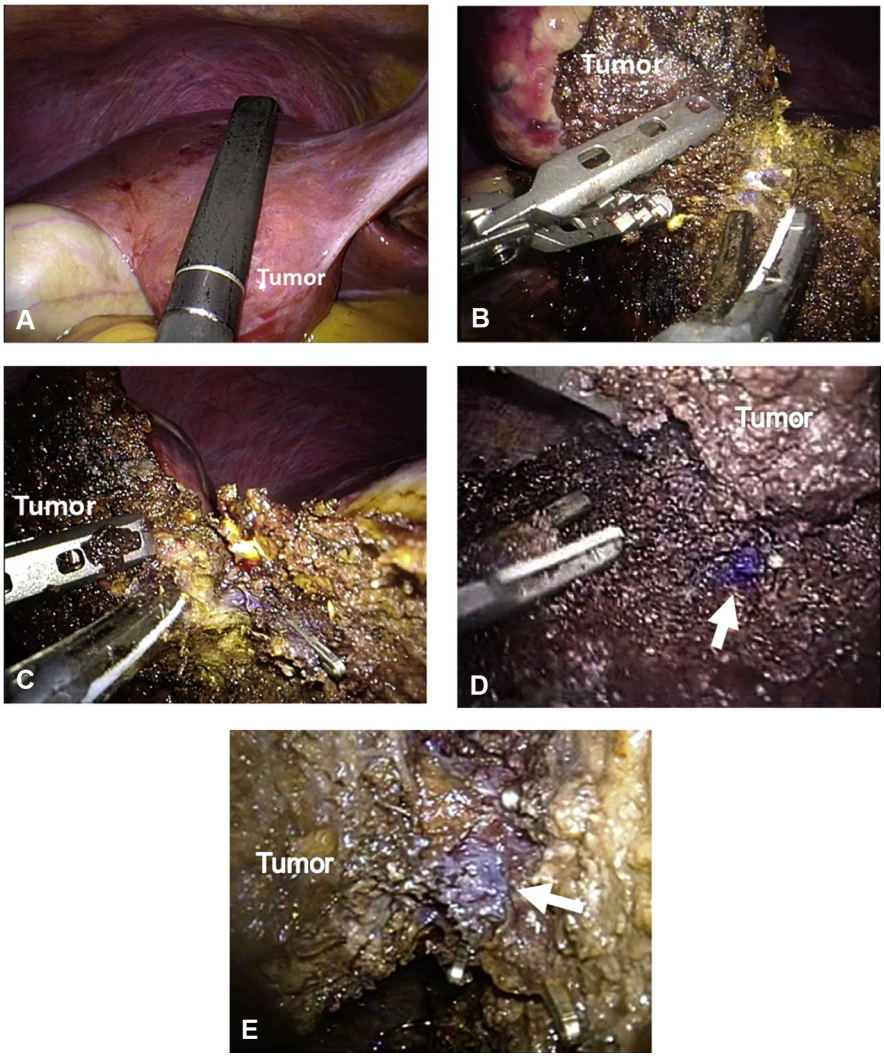

Figure 2. (A) Intraoperative view of a 72-year-old woman with hepatocellular carcinoma in segment 4. Laparoscopic intraoperative ultrasound was performed to obtain information on the free surgical margin and the anatomic relationship between the vessels and the tumor. (B) During transection, the local landmark with a tattoo (white arrow) was easily identified. (C) The vessels with the tattoo (white arrow) were dissected and clipped. (D) Intraoperative view of an 81-year-old woman with metastatic liver cancer in segment 6. The local landmark with the tattoo (white arrow) was also easily identified. (E) Intraoperative view of a 64-year-old man with metastatic liver cancer in segment 4. The local landmark with the tattoo (white arrow) was easily visible and the vessels with the tattoo were dissected and clipped.

the demarcation resulting from the extraparenchymal control of the hepatic flow. However, laparoscopic liver surgery has to minimize the amount of healthy parenchyma that is removed.[15] To address this issue, we demonstrated that the visualization of preoperative tattooing allowed for directed parenchymal transection, limited unnecessary exploration for the tumor, and decreased the risk of injury to the surrounding structures with the assistance of laparoscopic IOUS. Preoperative tattooing also helped to ensure an adequate oncologic margin because the tattoo was placed proximal to the lesion.

Mapping of liver using vital blue dye under IOUS is the gold standard for identifying segments and subsegments in the liver.[11,12,21] Sakairi and Makuuchi[22] reported previously that for visualization of the portal unit margin in the liver, the portal pedicle should be clasped with a surgical clip for injection of the dye. With this method, staining of the portal unit persists even after the resection

Table 2. Operative and Anesthetic Variables

Variable	Data (n = 7)
Total operative time, min, median (range)	169 (60–365)
Warm ischemic time, min, median (range)	21.4 (0–150)
Estimated blood loss, g, median (range)	82.9 (5–335)
Blood transfusion infusion, mL	0
Tumor exposure, n	
Yes	0
No	7
Surgical margin, mm, median (range)	6.3 (5–12)

is complete, and the margin of the portal unit within the parenchyma is easily followed during transection. The only major drawback of this IOUS-guided method is that it is difficult to clearly demarcate the liver segment using IOUS during laparoscopic liver surgery.

Our results in this study indicated that preoperative tattooing was safe without any complications. A potential complication of preoperative tattooing of the liver is bleeding from the liver parenchyma. Although there were some spots oozing on the surface of the liver at the sites where preoperative needles were inserted, when the liver was examined by a laparoscope, the oozing was easily controlled and stopped using electrocautery. Preoperative tattooing was performed successfully and allowed the surgeons to obtain a clear visualization of the tattooed area in the transection plane of the liver parenchyma; the lesion was fully resected with sufficient surgical margins in all cases. We were determined to perform laparoscopic liver resections in our cases with colorectal liver metastases that were reduced after chemotherapy. Although intraoperative localization of the lesion represented a prerequisite for liver resection, it was very difficult to identify an indistinct tumor and determine the safety margins using laparoscopic IOUS during laparoscopic surgery. When the lesion can be localized to certain segments, one strategy could be to perform an anatomic resection of the segment or segments in which the tumor was localized previously.[23] However, this is theoretical and far from clinical reality because anatomic liver resection is not required for colorectal liver metastases if a microscopically tumor-free surgical margin (R0) can be accomplished for the resection.[24-27] In our cases of colorectal liver metastases, we could target the lesion during liver transection with a high degree of accuracy using preoperative tattooing; this could lead to smaller resections with tumor-free margins. Preoperative tattooing could provide navigational assistance to the surgeon by allowing visualization of the clear staining of vessel landmarks in the area of division; this method could be applied to overcome this clinical problem.

Table 3. Outcomes of Patients Undergoing Liver Resections

Outcomes	Data (n = 7)
Morbidity (Clavien-Dindo classification)	
Biliary fistula	0
Postoperative bleeding	0
Infected fluid collection	0
Paresis of intestine	1 (grade I)
Liver failure	0
Others	0
Mortality, %	0
Hospital stay, d, median (range)	8.7 (6–12)

In this study, we demonstrated the potential of this technique to solve the dilemma of identification of nonvisualized and nonpalpable tumors, which are difficult to detect using intraoperative IOUS, or to obtain tumor-free surgical margins during laparoscopic liver resections. Additional case-matched studies to compare the tumor-free surgical margin associated with and without the use of tattooing are required. Finally, we believed that the precise localization offered by tattooing allowed us to optimize the preservation of healthy liver parenchyma to avoid unnecessary over-resection.

Author Contributions

Study conception and design: Aoki, Murakami
Acquisition of data: Aoki, Koizumi, Kusano, Fujimori, Enami
Analysis and interpretation of data: Aoki, Matsuda, Goto, Watanabe, Otsuka
Drafting of manuscript: Aoki
Critical revision: Aoki, Murakami

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